Stack-Unit Geologic Mapping:
Color-Coded and Computer-Based Methodology

Richard C. Berg and Mary R. Greenpool

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Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

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The test map for developing the computer-based and color-coded methodology was produced as part of a project to assess the regional mineral resource potential of the Paducah 1° × 2° Quadrangle. The project, part of the U. S. Geological Survey's Conterminous United States Mineral Assessment Program, was a cooperative study between the federal survey and the state geological surveys of Illinois, Indiana, Kentucky, and Missouri.

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CONTENTS

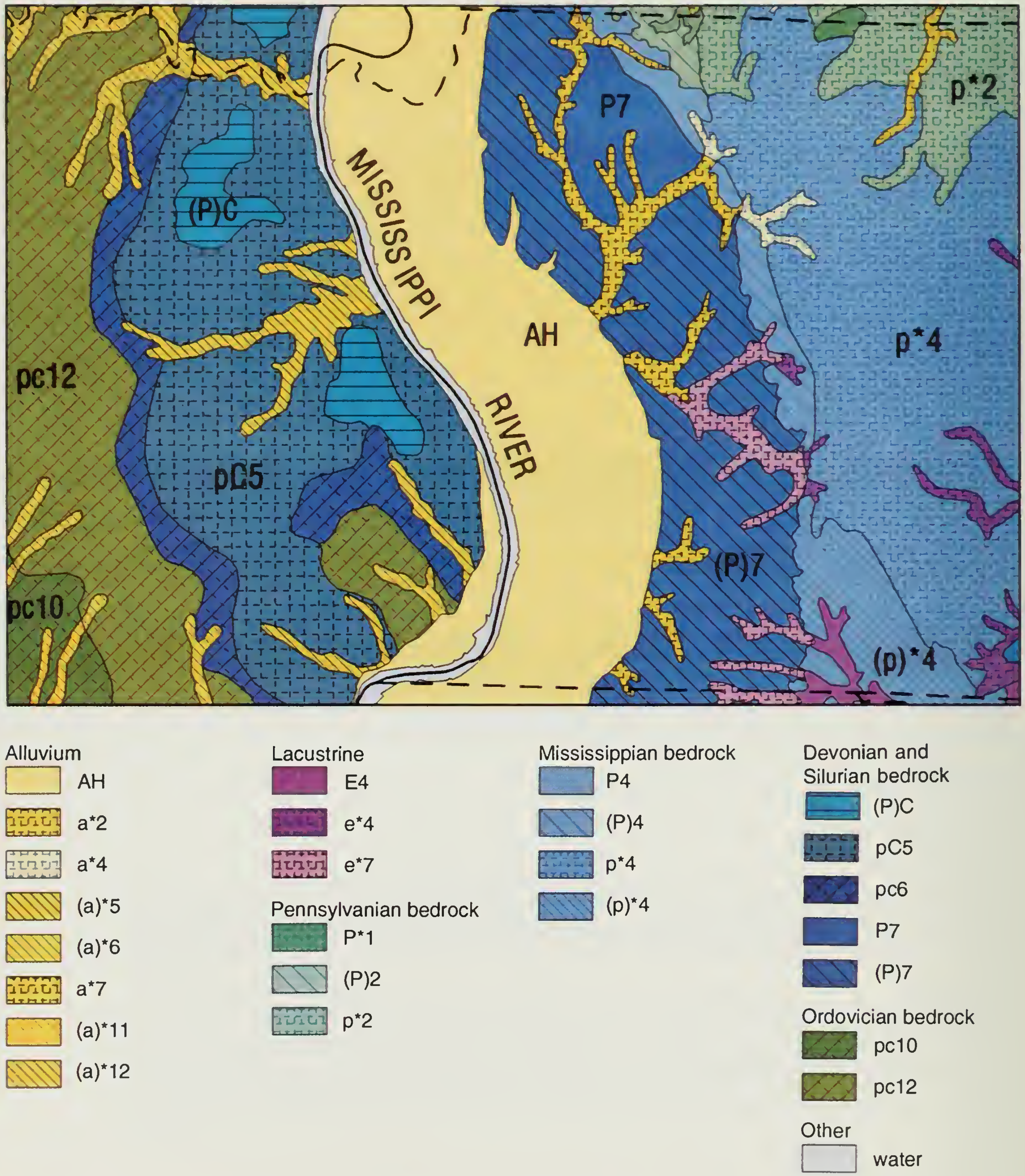


Plate 1 A portion of the *Stack-Unit Map of the Paducah 1° × 2° Quadrangle,* which was generated by computer and produced on the electrostatic plotter. The complete map is available as ISGS Open File Series 1993-5.

ABSTRACT

Representing lithostratigraphic successions or stack-unit geologic data on maps is a relatively recent technique in the United States for displaying diverse geologic relationships. Complex geologic data can be conveyed on a stack-unit map by color and pattern combinations. This paper describes a computer-based, color-coded methodology for representing geologic data to a depth of 15 meters on a stack-unit map.

The constructed map, a stack-unit map of the Paducah 1°x 2° Quadrangle, contains 785 individual polygons that depict 133 different successions of geologic materials to a depth of 15 meters. By using this color and pattern technique, both three-dimensional regional geologic trends and local geologic relationships become easily discernible to the viewer.

INTRODUCTION

A geologic stack-unit map can be constructed to show horizontal and vertical distributions, as well as stratigraphic position of earth materials (Berg et al. 1984). Geologic materials are not only distributed across the land surface, but also in layered or "stacked" sequences below the surface. Symbols or a color and pattern scheme indicate that a given geologic unit

- covers a specified *area*,
- ranges from a few to several meters *thick*,
- lies at a certain *depth* or within a certain *depth limit*,
- has specific *properties* (Berg et al. 1984).

Two approaches can be used to show such information. In the first, *alphanumeric codes* are used to label a vertical succession ("stack") of geologic units in each map area (Berg and Kempton 1988). The advantage is that all geologic information is displayed on the map and accessible, once the user is familiar with the symbols. The drawback is that the alphanumeric codes are printed on a white background, so the regional patterns and relationships among geologic materials are not visible. Without the discrete use of color on maps, abstract relationships of regional geology are not conveyed to the map user. Thus, an alternative approach was devised: *colors are systematically combined with patterns.*

Using the second approach to construct stack-unit maps is challenging because portraying a variety of geologic information without prolific, alphanumeric labels is difficult. Not only must a particular sequence or stack of units be clearly demarcated on the map, but the regional continuity of units must also be conveyed. The critical challenge is, however, to make the features on the map easily recognizable. When the challenge is met, geologic features such as alluvial valleys and glaciated areas are quickly discernible.

This paper presents such a methodology for constructing a map to represent complex, three-dimensional lithostratigraphic information by using a systematic scheme of colors and line and dot patterns. The representation technique and the resultant map were developed using a computer-based geographic information system (GIS). In this case, the GIS was used only for the production of the map; the geologic relationships were mapped by hand and data were then digitized by employing a computer program called ARC/INFO. The program was run on a Prime 9955 computer.

LITERATURE REVIEW

Representation of three-dimensional lithostratigraphic successions or stack-unit geologic relationships on maps is a relatively recent technique (at least in the United States) for displaying diverse geologic relationships (Kempton 1981). The technique resulted from the need to interpret basic geologic data for land-use planning (Kempton and Cartwright 1984, Kempton et al. 1989). Complex data on a stack-unit map can be simplified by combining similar materials according to such attributes as water-transmitting capacity, resource potential, or construction suitability. One of the earliest stack-unit maps was produced for De Kalb County, Illinois (Gross 1970). Several other stack-unit maps developed for county and regional studies in Illinois provided part of the information needed to produce the four stack-unit maps covering Illinois at a scale of 1:250,000 (Berg and Kempton 1988).

All but one of the published stack-unit maps of areas in Illinois are black and white and use labels to indicate the succession of materials within each map area. The exception, a stack-unit map of De Witt County, (Hunt and Kempton 1977), uses a very simple color coding system.

Color was used on interpretive maps to depict the potential for contamination of aquifers (Berg and Kempton 1984) and the potential for recharge of aquifers (Keefer and Berg 1990) throughout the state. Both maps are based on interpretations of the four stack-unit maps covering Illinois (Berg and Kempton 1988). For each of these two maps, more than 5,000 polygons and 800 sequences of geologic materials were interpreted according to generalized hydrogeologic properties of the individual mapped deposits. For the map showing contamination potential for aquifers in Illinois (Berg and Kempton 1984), 18 unique lithostratigraphic successions were identified from the stack-unit data. Each succession was colored with shades of red, yellow, and green. This "traffic-light" color scheme was used to identify the 18 ranked levels indicating the potential for aquifer contamination, and ranged from red (high potential due to shallow aquifers) to green (low potential due to an absence of aquifers). The potential for aquifer recharge map (Keefer and Berg 1990) used deeper subsurface information, yet it maintained the red, yellow, and green color scheme to identify seven levels of high to low potential for recharge to aquifers.

Other aquifer contamination potential maps, on which color was used to show the distribution of materials, were produced using the technique of Aller et al. (1987). Their procedure, known as DRASTIC, identifies buried drift and bedrock aquifers. Color is used to separate broad-based surficial geologic provinces. The technique has been used, most notably, for a contamination potential map of Wisconsin (Schmidt 1987) and for county contamination potential maps in Ohio (for example, Hallfrisch 1986). Like the Illinois contamination potential map, these maps are interpretations of geologic relationships for a specific purpose; therefore, details of material distributions are not portrayed.

Soller (in press) and Soller (1991) used color in a more sophisticated way to produce a U. S. Geological Survey map showing the thickness and character of Quaternary materials in the glaciated United States east of the Rocky Mountains. Colors were chosen to represent surface sediment types and progressively darker shades to indicate the total thickness of glacial drift over bedrock. Soller's map shows the existence of buried drift aquifers by using line patterns where aquifers are well documented.

Mappers in The Netherlands and Germany pioneered the use of colors, symbols, dots, lines, and labels to represent lithostratigraphy on stack-unit maps. The Dutch have published color maps similar to stack-unit maps since 1918 (Reinhold 1947). They produced two series of quadrangle maps: one at a scale of 1:200,000 (Nederlandsh Geologische Mijnbouwkundig Genootschap 1936–1953) and the other at a scale of 1:50,000 (Rijks Geologische Dienst 1951–1975). A summary map, including an explanation of mapping methodologies, was published in 1975 (Rijks Geologische Dienst 1975, Zagwijn and Von Staalduinen 1975). Germany's state geological surveys also produced stack-unit maps (Lange 1978) at a scale of 1:25,000 for a series of quadrangles. Although Dutch and German maps may be quite useful for some site-specific or area-specific screening and site or resource assessments, their mapped depth is generally limited to 2 meters; however, cross sections that extend to greater depths are provided.

For the methodology presented in this paper, we draw heavily on the conceptual mapping philosophies of Soller (in press) and his use of color and line and dot patterns, as well as from the maps developed in The Netherlands and Germany. The methodology presented in this paper allows, however, for production of maps that show the lithostratigraphic succession to a much greater depth than the Dutch and German maps. Additionally, the patterns and color scheme used to portray information in the ISGS system emphasize regional lithostratigraphic trends. The tables and figures in this paper illustrate the methodology. Solid colors, pattern types, and pattern colors must, in all cases, be carefully selected to achieve complementary schemes. This process becomes increasingly difficult with greater geologic complexity, especially where drift thickness varies.

METHODOLOGY

The test map for developing the color and pattern methodology was the *Stack-Unit Map of the Paducah 1°x 2° Quadrangle* (Berg and Greenpool, in preparation), which covers portions of Illinois, Missouri, Kentucky, and Indiana. This map was used because the ISGS, in a cooperative effort with the Missouri, Kentucky, and Indiana state geological surveys, and the U. S. Geological Survey (USGS), was already mapping the surficial deposits of this region to a depth of 15 meters for the USGS Conterminous United States Mineral Assessment Program (CUSMAP).

Detailed procedures for preparing a stack-unit map are discussed in Kempton (1981) and Berg et al. (1984). General steps are summarized below and illustrated in figure 1.

- Geologic data for the upper 1.5 meters are compiled from existing maps, such as the U. S. Department of Agriculture (USDA), Soil Conservation Service maps (fig. 1A); U. S. Geological Survey topographic maps (fig. 1B); and the ISGS map *Quaternary Deposits of Illinois* (Lineback 1979). Where detailed surficial maps are not available, original data are compiled.
- Drift thickness is plotted onto topographic base maps (fig. 1C); data are from geologic reports and maps, field observations, water well logs and samples, engineering boring logs or core samples, and controlled drilling for various projects. Physical and mineralogical properties from the various geologic units are compiled. Where possible, data on surficial units are checked against soil maps.
- Cross sections (fig. 1D) are constructed for some areas to help identify the continuity of subsurface materials.
- Surficial mapping data, including stack-unit data to a depth of 6 meters (fig. 1E), are taken from several published or unpublished maps and added to the base map.

For the Paducah 1°x 2° Quadrangle, stack-unit information to a depth of 15 meters was derived from previously published maps, spot field checking, and additional field mapping. Stacked successions of materials for the Illinois and Missouri portions of the map were well documented. For the Kentucky and Indiana portions of the map, stacked successions were interpreted from surficial maps and some subsurface information.

The original geologic maps and related lithostratigraphic information were drafted by hand and automated to produce a digital map at a scale of 1:250,000. The Illinois portion of the map was extracted from the digital version of the *Stack-Unit Map of Illinois* (Berg and Kempton 1988), whereas the Missouri, Kentucky, and Indiana portions of the map were digitized especially for this project. All maps were composited into a single GIS coverage and a tabular file was created to link selected colors and patterns to the lithostratigraphic codes. The capability to manipulate this tabular file provided considerable flexibility in assigning colors and patterns to the numerous lithologic combinations.

Assembling the Stack-Unit Map

The stack-unit map of the Paducah Quadrangle depicts 26 geologic materials that are defined by their diagnostic characteristics and continuity. These materials are identified in table 1 as seven glacial drift materials of Quaternary age, three semilithified deposits of Tertiary or Cretaceous age, three types of bedrock residuum, 12 bedrock lithologies ranging in age from Ordovician to Pennsylvanian, and one unit consisting of undifferentiated semilithified deposits and bedrock. The 26 materials occur in 133 different stacked sequences, distributed among 785 individual polygons on the Paducah map.

Materials are further differentiated according to thickness (for glacial drift, semilithified, and residuum materials) and depth beneath the surface (for bedrock). An alphanumeric coding system is used on the map to identify the 26 geologic materials and describe their thickness (table 1).

Letters of the alphabet represent drift, semilithified, and residuum materials.

- Uppercase letters (e. g., P) signify drift, semilithified, and residuum deposits that are greater than 6 meters.
- Uppercase letters enclosed by parentheses [e. g., (P)] represent units greater than 6 meters thick and continuous throughout the mapped area. Locally the units may be less than 6 meters thick, but they are always continuous.
- Lowercase letters (e. g., p) signify materials less than 6 meters thick.
- Lowercase letters enclosed by parentheses [e. g., (p)] represent deposits less than 6 meters thick and discontinuous within the mapped area.

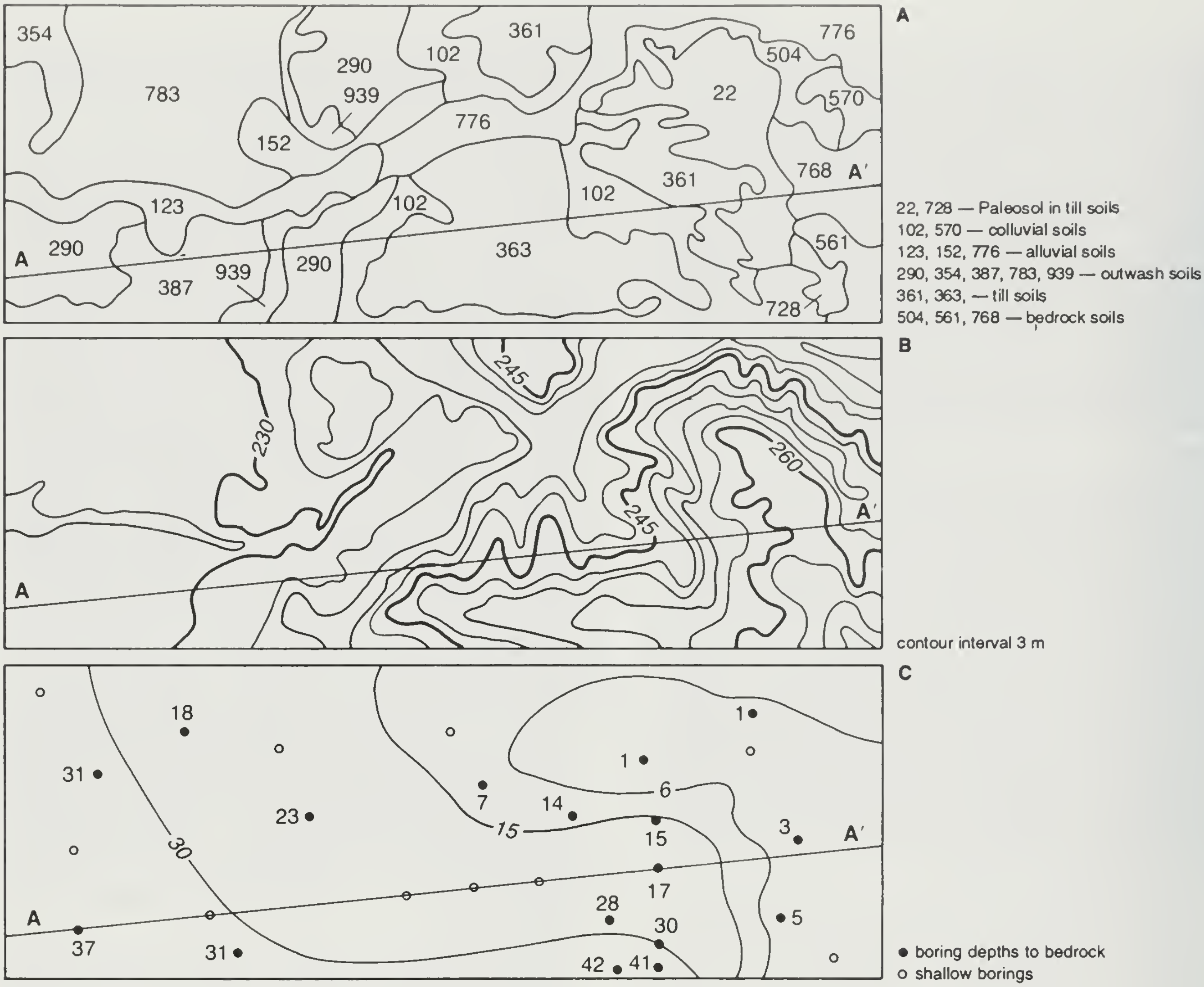
Numerals identify bedrock lithologies.

- Numbers preceded by an asterisk (e.g., *2) represent bedrock that occurs within 6 meters of the surface.
- Plain numbers (e. g., 2) indicate bedrock 6 to 15 meters deep.
- Numbers enclosed by parentheses [e.g., (2)] indicate that the bedrock surface is at or slightly below the 15-meter depth.

Assigning General Colors

Major color categories were assigned to groups of geologic materials on the basis of the uppermost material underlying loess or residuum. Borrowed from the established colors used on the ISGS map, *Quaternary Deposits of Illinois* (Lineback 1979), and numerous bedrock maps, the following scheme is used:

- yellow = alluvium
- orange = outwash sand and gravel
- purple = lacustrine deposits



- drab green = dune sand
- pink or red = diamicton
- brown = semilithified deposits
- green = Pennsylvanian bedrock
- blue = Mississippian bedrock
- dark blue = Devonian and Silurian bedrock
- olive green = residuum of Ordovician bedrock.

In addition, surface water bodies are light blue and disturbed land (primarily from mining activities) is represented by black.

Assigning Color Shades

The 133 different successions of units are subdivided into 77 groups according to similarities in the stacking order of specific units. These groups were determined on the basis of lithologic similarities rather than on thickness and continuity properties (table 2). In this manner, similar successions (except those containing alluvium) are assigned an identical shade. For example, the same shade of pink, is used for pg*2, pg2, p(g)*2, and pG2, which represent stacked units of Peoria Loess and Roxana Silt (p) overlying Glasford Formation diamicton (g) overlying Pennsylvanian sandstone (2). The use of color shades to represent lithologic differences between stack units is essential for illustrating the regional continuity of materials across the map area.

Alluvium is the only group not shaded according to the above color scheme. We chose to represent alluvium with a distinctive color, yellow, because it provides the viewer a sense of topography; alluvium always occurs at the surface in lowlands. In addition, yellow is the established color for alluvium on the ISGS Quaternary deposits map (Lineback 1979). Alluvium overlies almost all other sequences of geologic materials, and its representative color of yellow lacks a sufficient number of shades to distinguish the many possible stack-unit combinations; therefore, only three shades of yellow are used to distinguish stacked units containing alluvium. A total of 55 colors are used on the Paducah map: three represent 25 sequences containing alluvium and 52 colors repre-

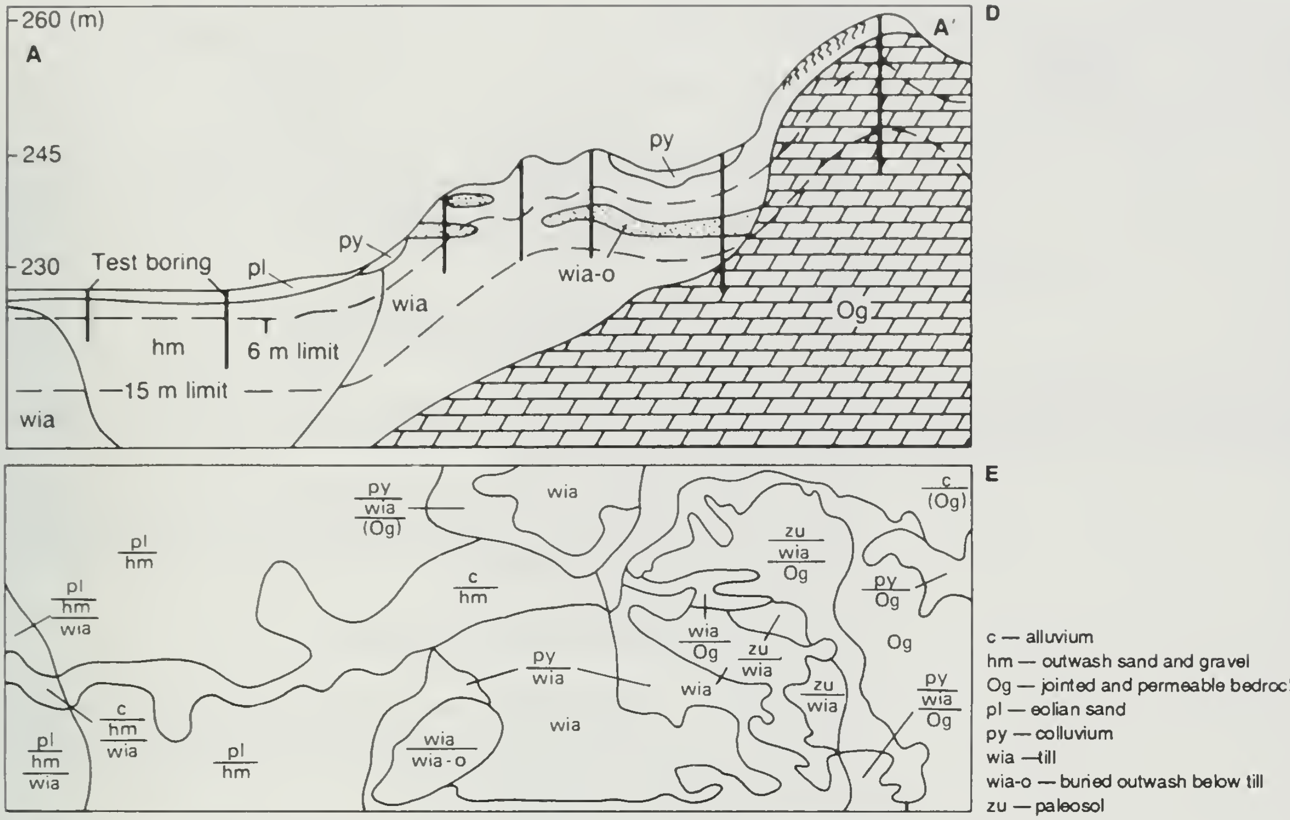


Figure 1 Constructing a stack-unit map requires combining data from a wide variety of sources, such as USDA Soil Conservation Service maps (A) and USGS topographic maps (B). Controlled drilling provides subsurface data (C). Cross sections (D) are constructed to help identify continuity of subsurface materials. Surficial mapping data and subsurface information are combined to make the stack-unit map (E).

sent the sequences without alluvium. The areas on the Paducah Quadrangle that contain alluvium, however, are effectively differentiated on the map by using the pattern overlay scheme discussed below.

Assigning Pattern Overlays

The 133 stack units are grouped a second time into 18 categories according to generalized material properties, as well as to the thickness and continuity of materials within the succession (table 3). If the uppermost unit is less than 6 meters thick, overlays of dot and line patterns differentiate map areas of the same color shade. A map overlay pattern is not used if the uppermost drift, semilithified unit, bedrock, or residuum deposit is greater than 6 meters thick. For example, one overlay pattern (table 3, group 5, subgroup 9) represents all drift materials overlying bedrock within 6 meters of the surface. Thus, a*1, d*2, g*1, and p*4 have the same overlay line pattern (small, broken, vertical and horizontal lines), but they are differentiated by the color shade that underlies the pattern. This shade indicates the uppermost geologic material underlying loess or residuum: a*1 is yellow, d*2 is drab green, g*1 is red, and p*4 is blue.

The 18 different patterns are organized into five general groups according to similar thickness and continuity properties for the *uppermost* unit (including loess and residuum) or where drift material is inclusively greater than 15 meters thick.

PMK, (P)MK, pmK, (p)mZ, and pG (table 3) are representative sequences of stack units that fall into each of the five general groups. The first four sequences are differentiated according to the thickness and continuity of P (Peoria Loess and Roxana Silt), the uppermost unit.

- PMK (group 1) does not have a line or dot pattern because the uppermost unit, P, is greater than 6 meters thick.
- (p)mZ (group 3) is represented by a narrow line pattern because the uppermost unit, (p), is discontinuous throughout its mapped area.

Table 1 Alphanumeric code and description of lithologic materials.

Material >6 m thick	Material <6 m thick	Nonlithified and semilithified material
A	a	Cahokia Alluvium Deposits in floodplains and channels of modern rivers and streams; mostly poorly sorted sand, silt, or clay containing local deposits of sand and gravel; includes some loess on higher surfaces. In Missouri, it contains large amounts of chert fragments derived from cherty residuum and bedrock.
D	d	Parkland Sand Windblown sand; well sorted, medium grained sand in dunes and thick sheet deposits between dunes; locally interbedded with loess.
E	e	Carmi Member of Equality Formation Largely slackwater lake sediments dominated by stratified silt and clay; deposited in valleys tributary to major river valleys; commonly covered by <2 m of loess.
H	h	Mackinaw Member of Henry Formation Sand and gravel; generally well sorted and stratified; deposits in valleys, mostly glacial outwash in former valley trains and terrace remnants of former valley trains. In Missouri, it is derived from nonglacial cherty residuum and cherty bedrock; commonly covered by <2 m of loess.
P	p	Peoria Loess and Roxana Silt Windblow silt with local lenses of fine grained sand.
G	g	Glasford Formation Glacigenic diamicton with interbedded sand and gravel; surficial clay, silt, sand, and gravel deposits. The Glasford is divided into several members; generally prominent Sangamon Soil occurs in uppermost deposits.
O	o	Sand and gravel within the Glasford Formation
M	m	Mounds Gravel Mostly gravel on uplands; brown chert pebbles; high remnants of former terrace levels interpreted to be of Pliocene–Pleistocene Age.
T	t	Tertiary deposits Clay, sand, and glauconitic sand.
K	k	Cretaceous deposits Largely nonmarine sand containing beds of lignitic silt, clay, lignite, and gravel; mainly derived from metamorphic rocks of the Piedmont to the east-southeast.
C	c	Cherty residuum Residuum developed from weathering of bedrock; mostly composed of chert fragments.
S	s	Sandy residuum Residuum developed from weathering of bedrock; mostly composed of sandy materials.
R	r	Sandy cherty residuum Residuum developed from weathering of bedrock; mostly composed of sand and chert fragments.
Z	z	Tertiary, Cretaceous, or Mississippian rocks undifferentiated (Kentucky only —insufficient information).
( )		Continuous throughout map area but <6 m thick in some areas. If unit is lowermost, it may not be present above the 15 m depth, but it generally lies at or just below 15 m.
	( )	Not continuous throughout map area. If unit is lowermost, it may not be present above the 15 m depth, but it generally lies at or just below 15 m.

Table 1 *continued*

Between 6–15 m of surface	Between 0–6 m of surface	Lithified material
1	*1	Pennsylvanian rocks Mainly shale.
2	*2	Pennsylvanian rocks Mainly sandstone; some shale mapped in Kentucky.
3	*3	Mississippian rocks Mainly shale.
4	*4	Mississippian rocks Lower part dominantly limestone; upper part interbedded limestone, shale, and sandstone mapped in Illinois; mainly cherty limestone in Missouri; may include limestone, sandstone, and shale in Kentucky.
5	*5	Devonian rocks Limestone, chert, and shale.
6	*6	Silurian rocks Limestone, chert, and shale.
7	*7	Devonian and Silurian rocks Mainly dolomite and limestone.
8	*8	Ordovician rocks Mainly shale.
9	*9	Ordovician rocks Sandstone, dolomite, and chert.
10	*10	Ordovician rocks Mainly dolomite with some shale and sandstone.
11	*11	Ordovician rocks Mainly sandstone.
12	*12	Ordovician rocks Limestone and dolomite with some shale and sandstone.
( )		Unit may not be present above the 15 m depth, but generally it lies at or just below 15 m.

- (P)MK (group 4) is represented by a wide line pattern because the uppermost unit, (P), is usually greater than 6 meters thick (but it may be less), and always continuous throughout its mapped area.
- pmK (group 5) is represented by a cross hatch pattern because the uppermost unit, p, is always less than 6 meters thick.
- pG (group 2) is represented by a dot pattern to indicate that the drift material is inclusively greater than 15 meters thick.

Stack units within a major group are further differentiated on the basis of ***underlying*** unit properties, such as continuity, thickness, material type, and the depth of bedrock beneath the surface. For instance, in the general pattern group for continuous upper units less than 6 meters thick (table 3, group 5), aE(m) in subgroup 1 is differentiated from ae4 in subgroup 5 on the basis of the thickness of Equality Formation deposits (e vs E) and the continuity and material differences between semilithified material (m) and bedrock material 4. Sequences ae4 in subgroup 5 and ae*4 in subgroup 6 are distinguished by an *, which represents bedrock occurring within 6 meters of the surface for the latter. The complete list of pattern assignments is shown in table 3.

Assigning pattern overlay colors Color has also been added to the overlay pattern to differentiate the ***lowermost*** unit of a succession, regardless of the overlying materials.

- Red pattern represents sequences containing Ordovician rocks.
- Black pattern represents Silurian and Devonian rocks.
- Blue pattern signifies Mississippian rocks.
- Green pattern signifies Pennsylvanian rocks.
- Purple pattern represents sequences that contain no bedrock materials within a depth of 15 meters.

The use of color overlay patterns to represent alluvium is particularly important because stack units can only be differentiated by the color of the overlay pattern. Matching pattern colors with underlying materials follows the above color scheme. For example, a*1, a*7, and a*10 have the same shade of yellow background and the same

Table 2 Geologic sequence groups with color shade assignments (based on a stack sequence regardless of thickness or continuity).

Alluvium (yellow)	Outwash sand and gravel (orange)	Lacustrine deposits (purple)	Dune sand (drab green)	Diamicton (pink or red)	Semi-lithified deposits (brown)	Penn. bedrock (green)	Miss., Devonian, Silurian bedrock (blue)	Residuum over Ordovician bedrock (olive green)
aE	H	E	(d)AH	G	PMK (P)MK (P)mK pMK pmK	*1	*4	pr9
(a)eg1		EH eH	dH	Gog	PmK7	p*1	P4 (P)4 p*4 (p)*4	pc10
aE(m)		(E)G(1) e(g)*1 eG(1) eG1	dmT	Gog1	PMT pMT pmT (p)MT	*2	(P)C PC4 (P)c4 pc4	ps11
a(e)M(K)		e(m)K	d*1	Gog(1)	pMZ pmZ (p)mZ	P2 (P)2 p*2 (p)*2	p*5 pC5	(P)c12 pC12 pc12
a(e)M(T)		emT	d*2	G1 g*1	pM4	(P)2,4	pc6	
aE(1) ae*1		E(K) eK		G2 g*2 (g)*2	(P)K pK		P7 (P)7	
a(e)*2		E(1)		pG			P7,8 (P)7,8	
ae4 ae*4 (a)E4		E1 e*1		pGog (p)Gog				
AH aH (a)H		E2 e*2		pG1 pg1 pg*1				
aH(m) (a)H(m)		E4 e*4		(P)g2 (P)g(2) pG2 pg2 pg*2 p(g)*2				
a(h)*4		E7 e*7		pg*3				
ag*4				pG(4) pg4 pg*4				
aM(K)								
A(m)T (a)MT								
aK								
aT								
a*1								
a*2								
A4 a*4 (a)*4								
(a)*5								
(a)*6								
a*7								
a*10 (a)*10								
a*11 (a)*11								
(a)*12								

——— delineates subgroups and, except for alluvium, represents a color shade variation within the major color group.
* bedrock that occurs within 6 meters of the surface.

Table 3 Geologic sequence groups with pattern assignments (based on thickness and continuity of units).

Group 1 Continuous upper unit >6 m thick		Group 2 Drift unit >15 m thick		Group 3 Discontinuous unit <6 m thick throughout area			Group 4 Continuous uppermost drift unit usually >6 m thick		
		1	2	1	2	3	1	2	3
A(m)T	Gog1	aE	(a)H	(a)H(m)	(a)eg1	(a)*4	(P)C	(P)g2	(P)2
AH	G1	aH	(d)AH	(a)E4	(p)mZ	(a)*5	(P)K	(P)g(2)	(P)2,4
A4	G2	eH	(e)H	(p)MT		(a)*6	(P)MK	(P)mK	(P)4
PE	PMT	dH	(p)Gog			(a)*9	(E)G(1)	(P)c4	(P)7
E	PMK	pG				(a)*11		(P)c12	(P)7,8
EH	PmK7	pGog				(a)*12			
E(K)	*1					(g)*2			
E(1)	*2					(p)*2			
E1	*4					(p)*4			
E2	P2								
E4	P4								
E7	PC4								
G	P7								
Gog	P7,8								
Gog(1)									

Group 5 Continuous uppermost drift unit <6 m thick								
1	2	3	4	5	6	7	8	9
aE(m)	eG1	aE(1)	dmT	ae4	ae*1	a(e)M(K)	a(e)*2	a*1
aH(m)	pG1	eG(1)	emT	pg1	ae*4	a(e)M(T)	a(h)*4	a*2
aK	pG2	pG(4)	pmK	pg2	ag*4	e(m)K	e(g)*1	a*4
aM(K)	pM4		pmT	pg4	pg*1		p(g)*2	a*7
aM(T)	pC5		pmZ	pc4	pg*2			a*10
aT	pC12			pc6	pg*3			a*11
eK				pr9	pg*4			e*1
pMK				pc10				e*2
pMT				ps11				e*4
pMZ				pc12				e*7
pK								d*1
								d*2
								g*1
								g*2
								p*1
								p*2
								p*4

pattern, but they each have a different colored pattern to distinguish their bedrock. A green pattern overlay corresponding with Pennsylvanian rocks is given to a*1; a black pattern corresponding with Silurian and Devonian rocks is given to a*7; and a red pattern corresponding with Ordovician rocks is given to a*10. Three exceptions to this system resulted because of limited color-pattern options.

(1) Since blue and green are indistinguishable when overlaid on yellow, they are never used together in the same pattern assignment.

(2) Some color patterns disappear on some solid colors.

(3) Similar successions with the same bedrock material (e. g., Pennsylvanian), but different lithologies (e.g., shale vs sandstone), are distinguished by different colors within patterns. For example, the standard green pattern overlay representing Pennsylvanian rocks is used for a*1; however, because of limited color options, an orange pattern is used to represent the bedrock in stack unit a*2.

Additional differentiation An additional differentiation is made such that bedrock within 6 meters of the surface is generally represented by fine patterns (table 3, groups 3 and 5, subgroups 6-9); bedrock deeper than 6 meters below the surface is represented by coarse patterns (table 3, groups 4 and 5, subgroups 1-5). Also, dot patterns only represent areas where all drift units are greater than 15 meters thick and the upper unit is less than 6 meters thick.

Labels have been retained on the map to help the user become quickly familiar with lithostratigraphic successions and to reduce the need for frequent cross-referencing between the map and the legend.

CONCLUSIONS

The computer-based, color-coded methodology produces, in a practical way, a final colored map representing very complex, three-dimensional geologic relationships. The final color map is relatively easy to construct, given adequate input data and an efficient database management system to manipulate data. Pattern overlays coordinated with colors can be devised so as to translate relatively dense geological information into a visually meaningful map. The colored stack-mapping technique, as demonstrated, illustrates the geologic complexities of the near-surface deposits within the Paducah Quadrangle.

A portion of the final map is shown in plate 1. The systematic use of colors with line and dot patterns represents complex three-dimensional lithostratigraphy in a way that allows the map user to visualize regional geologic trends and understand local geologic relationships more quickly. For example, areas where drift is greater than 15 meters thick are easily shown by lack of overlay pattens. One can immediately see where bedrock occurs within 6 meters of the surface by focusing on fine pattern overlays. Lowland areas can be easily distinguished by the yellow areas on the map representing alluvium deposits.

Should detailed geologic information for a particular map area be needed, the labels for individual map areas or polygons can be examined to determine the complete sequence of materials. Most importantly, this mapping technique allows detailed local information to be portrayed within the context of broader regional trends. The map is especially designed not to overwhelm but to aid the user in identifying surface and subsurface geologic relationships. The user-friendly model or map is very important for any derivative maps of land-use or mineral resource potential that may be made from this stack-unit map.

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